

Blazars and the Black Hole Finder Probe EXIST

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10/22/04

Plan of Talk:

- X-Ray and TeV Gamma-Ray Observations of Blazars
- EXIST Related Research and Development:
 - CZT Detectors;
 - Shield/Collimator Assembly.
- Summary

Collaborators and Funding

Washington University:

T. Garson;
S. Hughes;
I. Jung;
J. Perkins.

J. Buckley.

Modeling:

P. Coppi (Yale).

Funding:



CZT Development:

A. Burger;
M. Grosza.

VERITAS Collaboration:

T. Weekes (S.A.O.) et al.

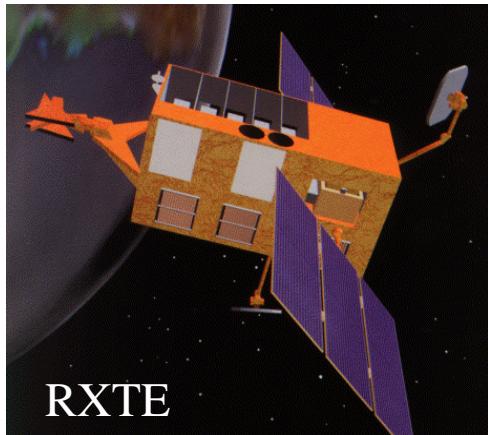
Exist Collaboration:

J. Grindlay (Harvard) et al.

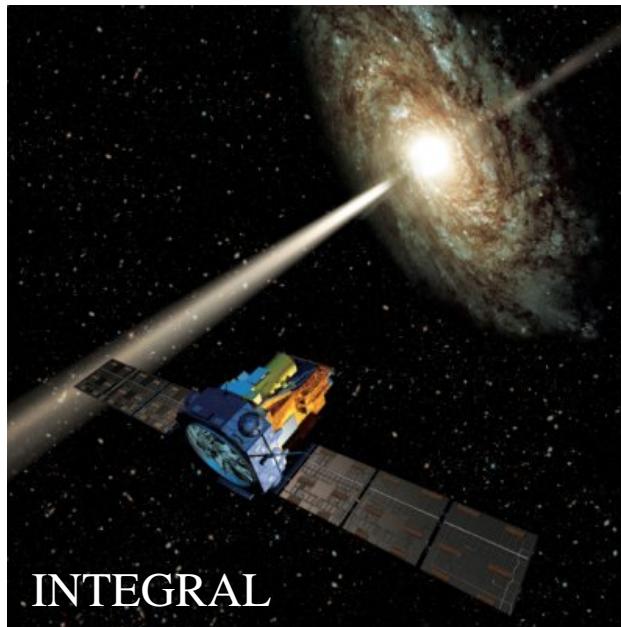


DOE

X-Ray Observations



RXTE



INTEGRAL



ASTRO-E2

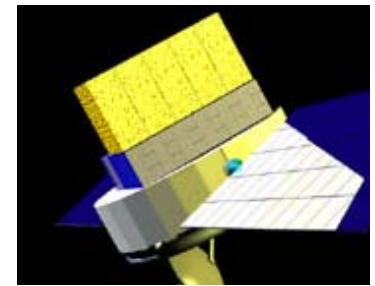
Gamma-Ray Observations



Whipple 10m

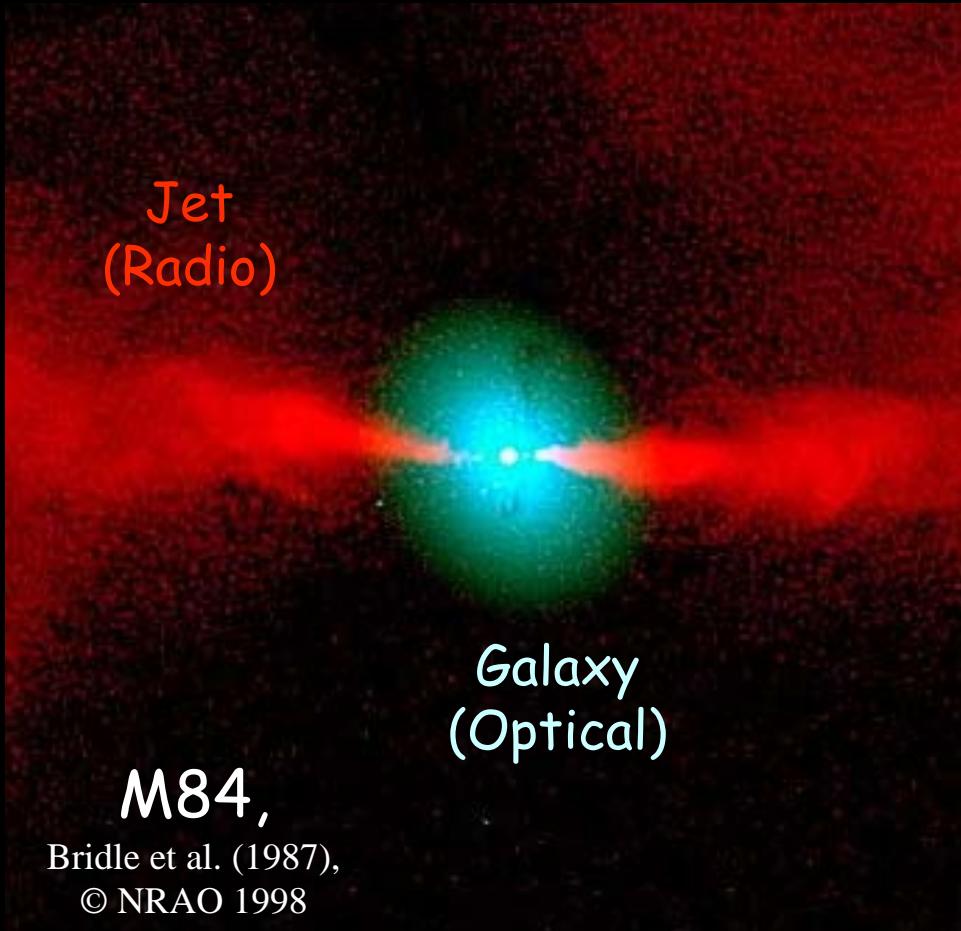


4 x VERITAS
12m (Oct' 06)



GLAST

Active Galactic Nuclei and Blazars



10 Powers of 10



VLBA



VLA

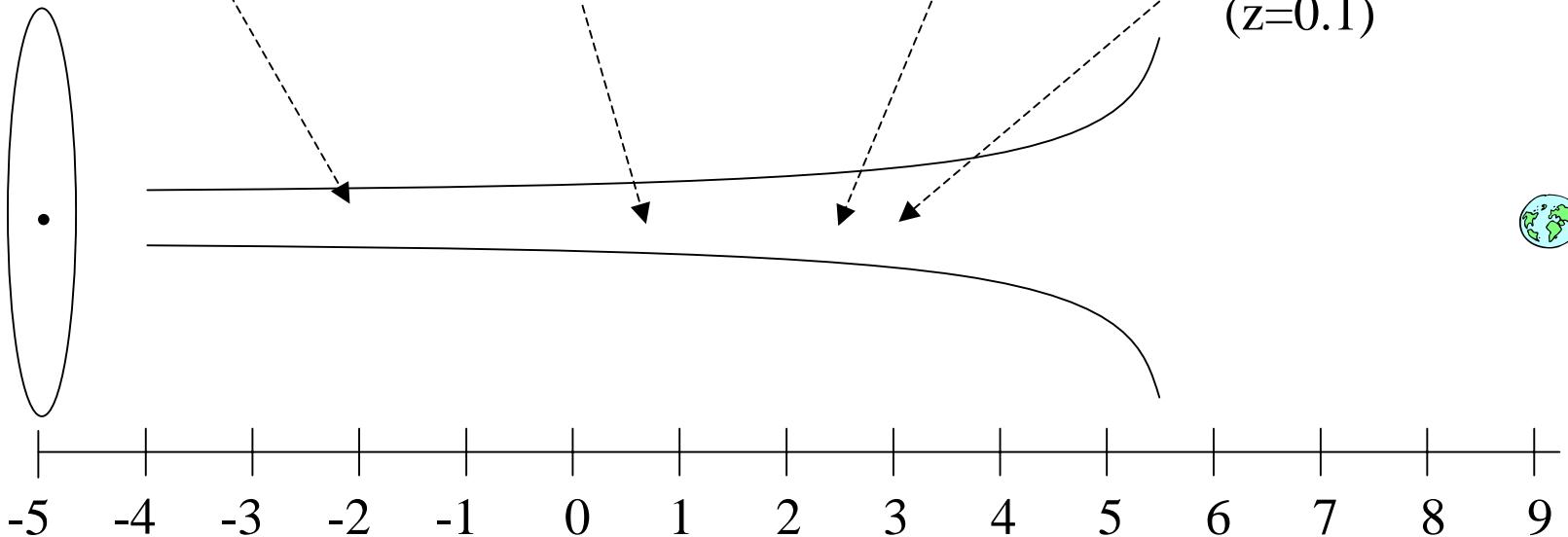


Chandra

3mas \sim 5 pc

0.1'' \sim 200 pc

0.5'' \sim 1 kpc
(z=0.1)



Black Hole (10^{-5} pc)

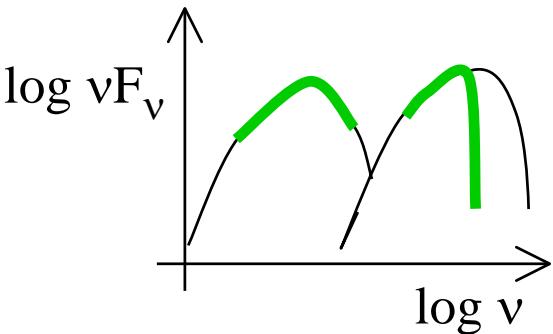
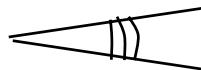
Log (D/pc)

Accretion Disk (10^{-3} pc)

BLR (10^{-2} pc)

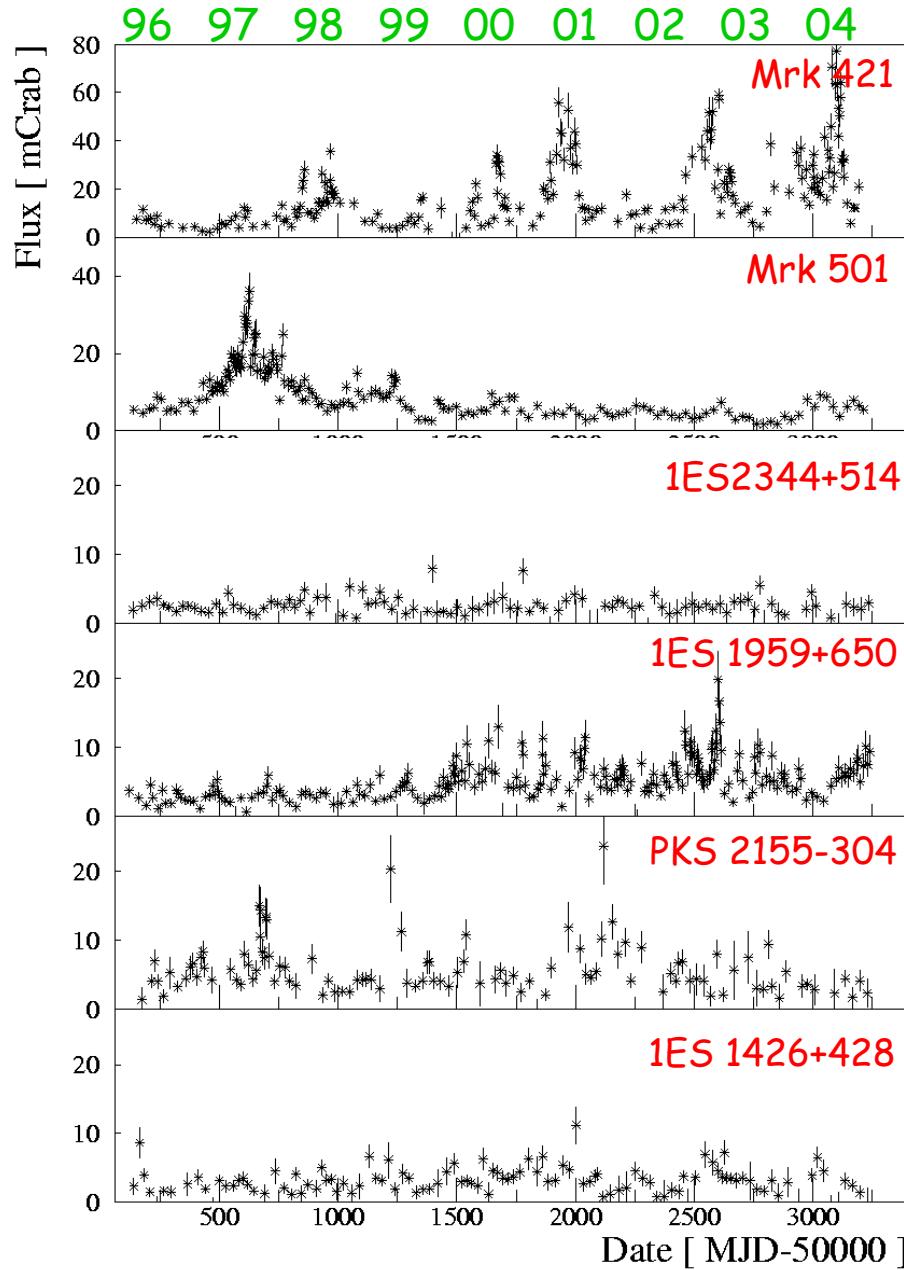
NLR (1-100 pc)

Scientific Objectives



- 1) Emission Mechanism & Particle Acceleration
- 2) Jet-Properties;
- 3) Jet-Black Hole Connection.
- 4) Role of Black Holes in "Cosmic Eco-Systems".
- 5) Measure Total Electromagnetic Luminosity of the Universe.

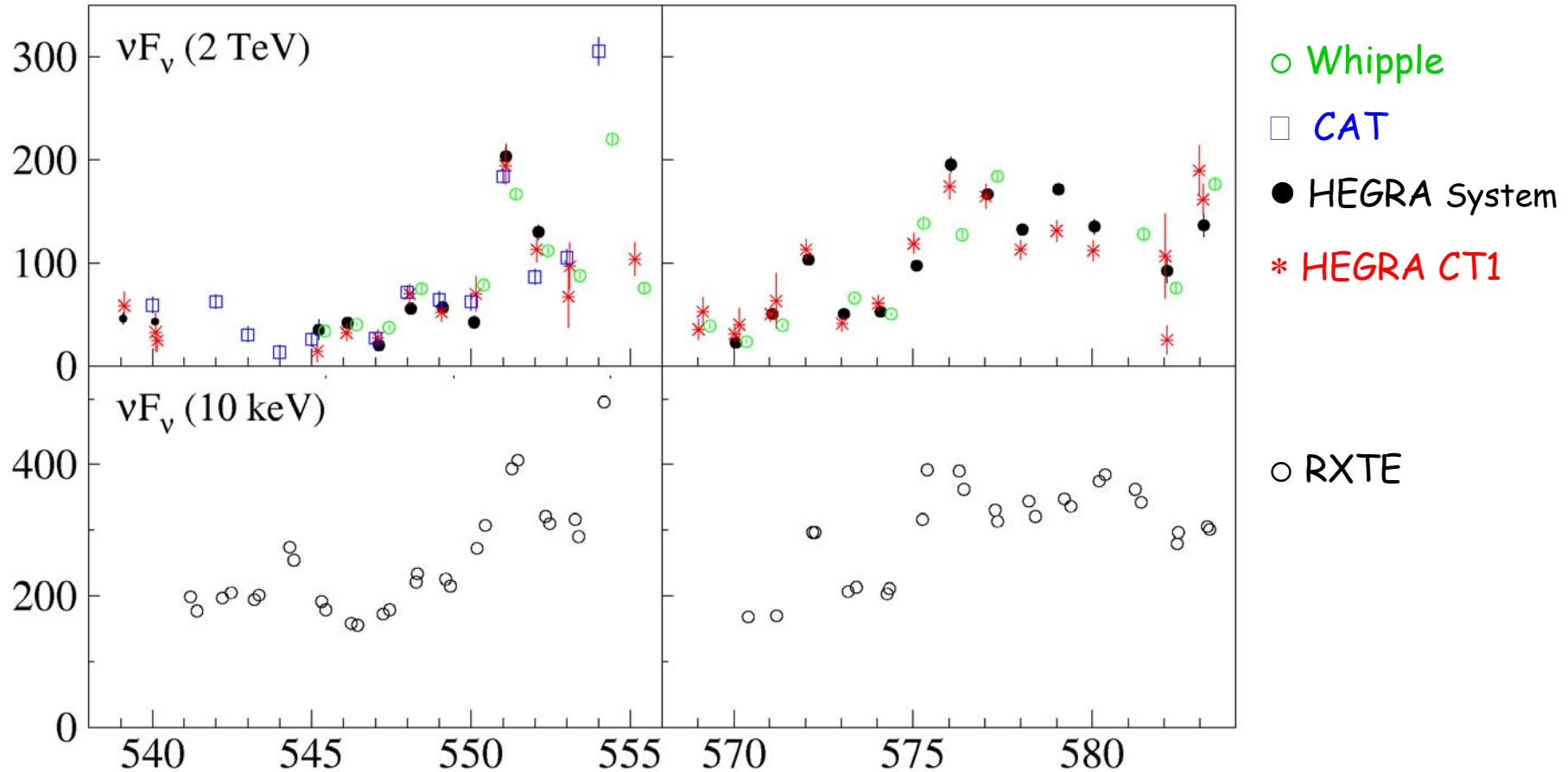
TeV Blazars - RXTE ASM Overview



RXTE ASM
(2-12 keV)

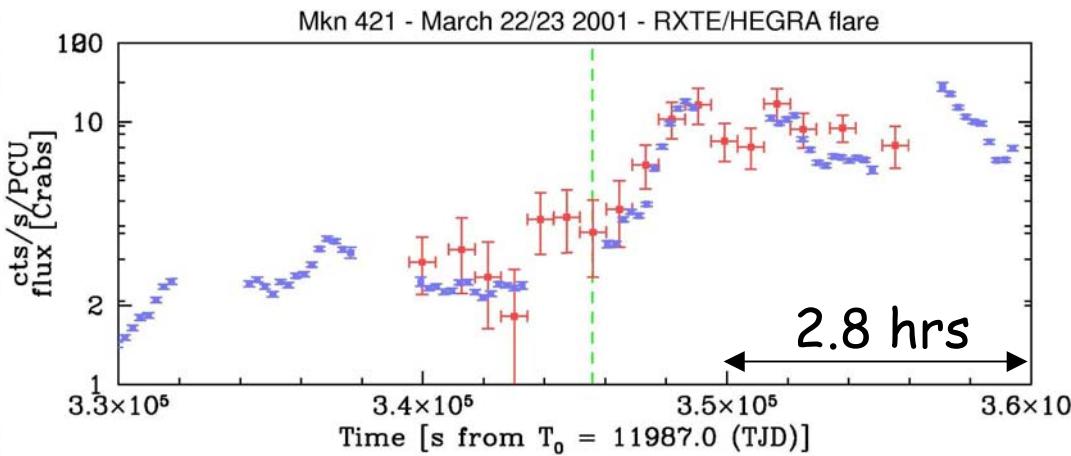
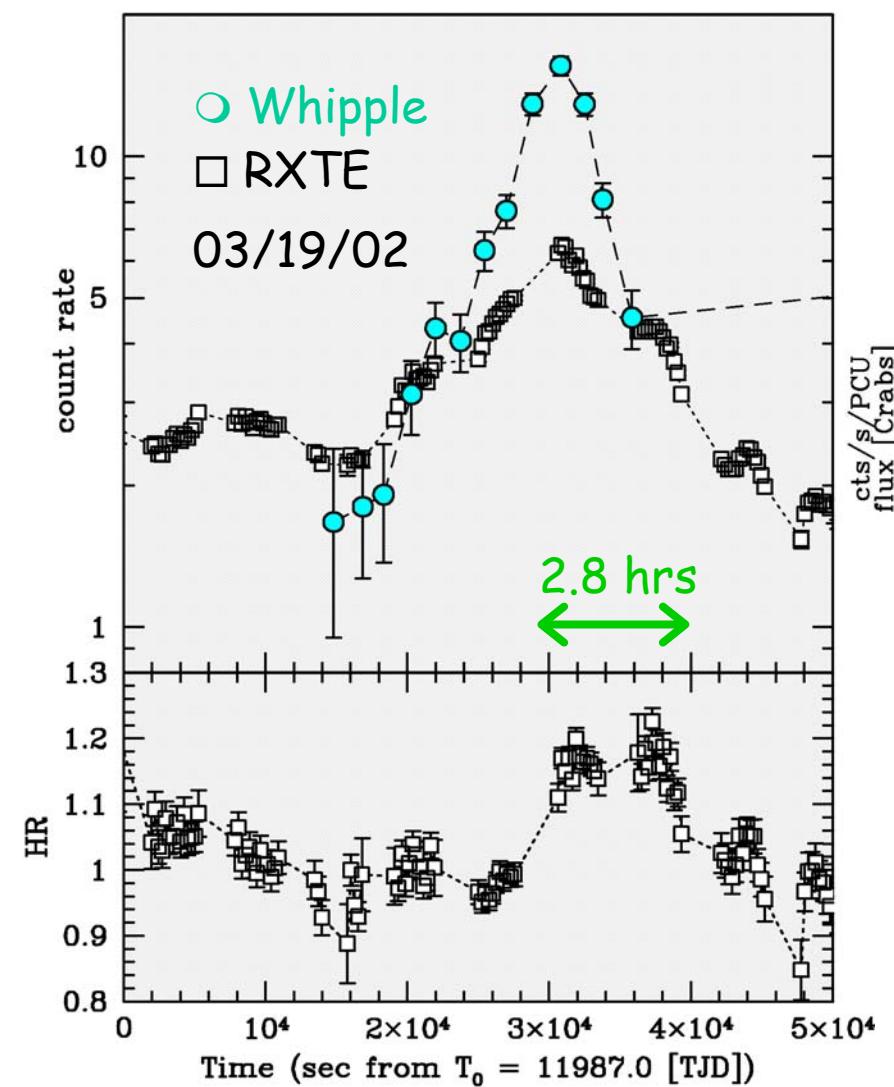
Krawczynski et al. (2004)

X-Ray/Gamma-Ray Observations of Mrk 501



Krawczynski et al. (2002)

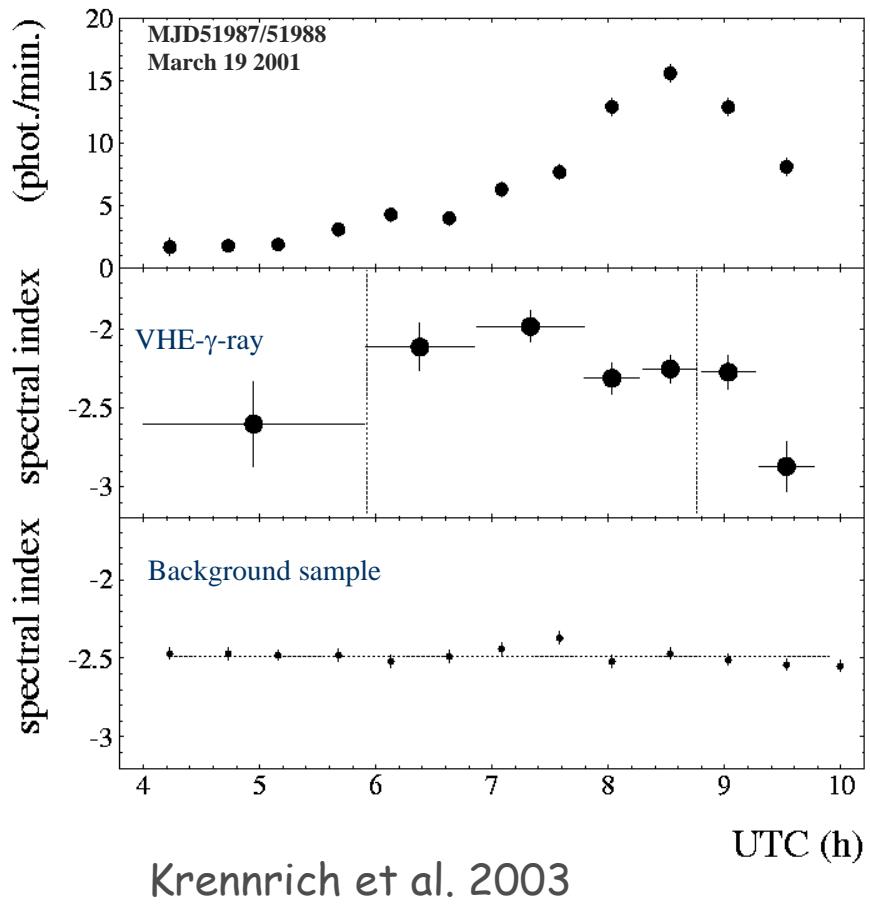
Mrk 421 - 2001



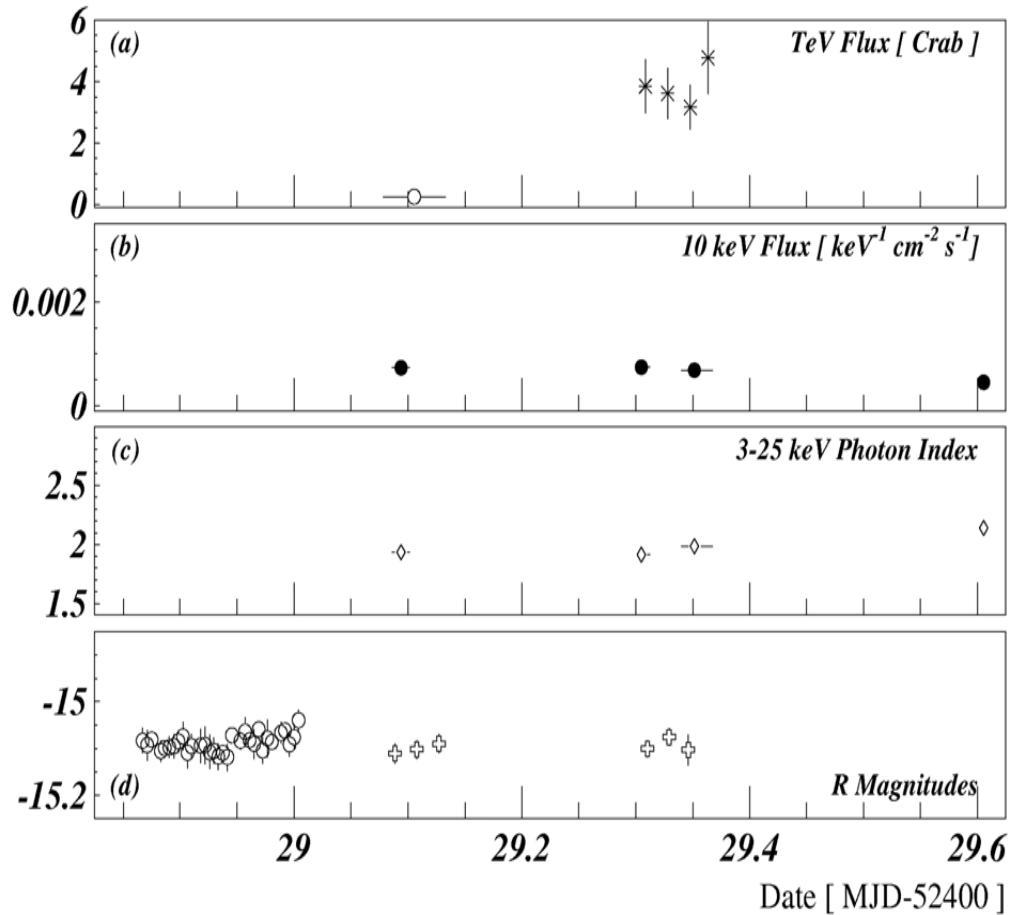
Excellent X/TeV
Correlation →
Co-spatial Emission.

Fossati, Buckley, Horns,
Krawczynski et al. 2004

Spectral Variability at TeV Energies



Orphan Flare of 1ES 1959+650



June 4, 2002

Krawczynski, Hughes et al. 2004

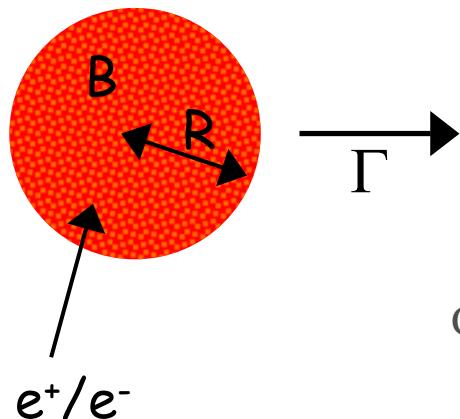
Astrophysical Interpretation

(1) Flux Variability Time Scales:

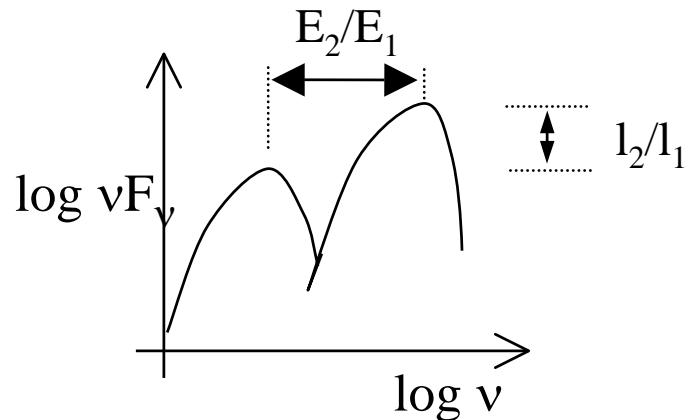
$$R \leq \delta_j \cdot c \cdot \Delta t = 5 \cdot 10^{15} \cdot \frac{\delta_j}{50} \cdot \frac{\Delta t}{1\text{hr}}$$

$$\delta_j \geq 10 \cdot \left(\frac{\Delta t}{1\text{hr}} \right)^{1/5}$$

(3) Time
Dependent
Modeling:

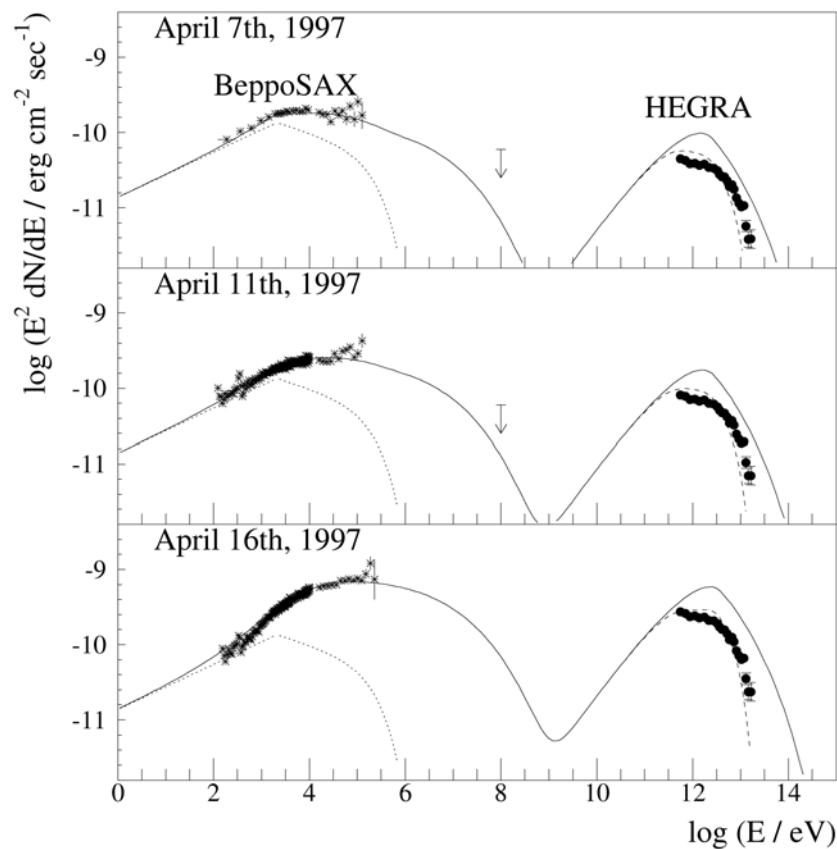


(2) Analysis of Spectral Energy Distribution:



Krawczynski,
Coppi, Hughes
et al. 2002

Time Dependent Modeling of Mrk 501 Data

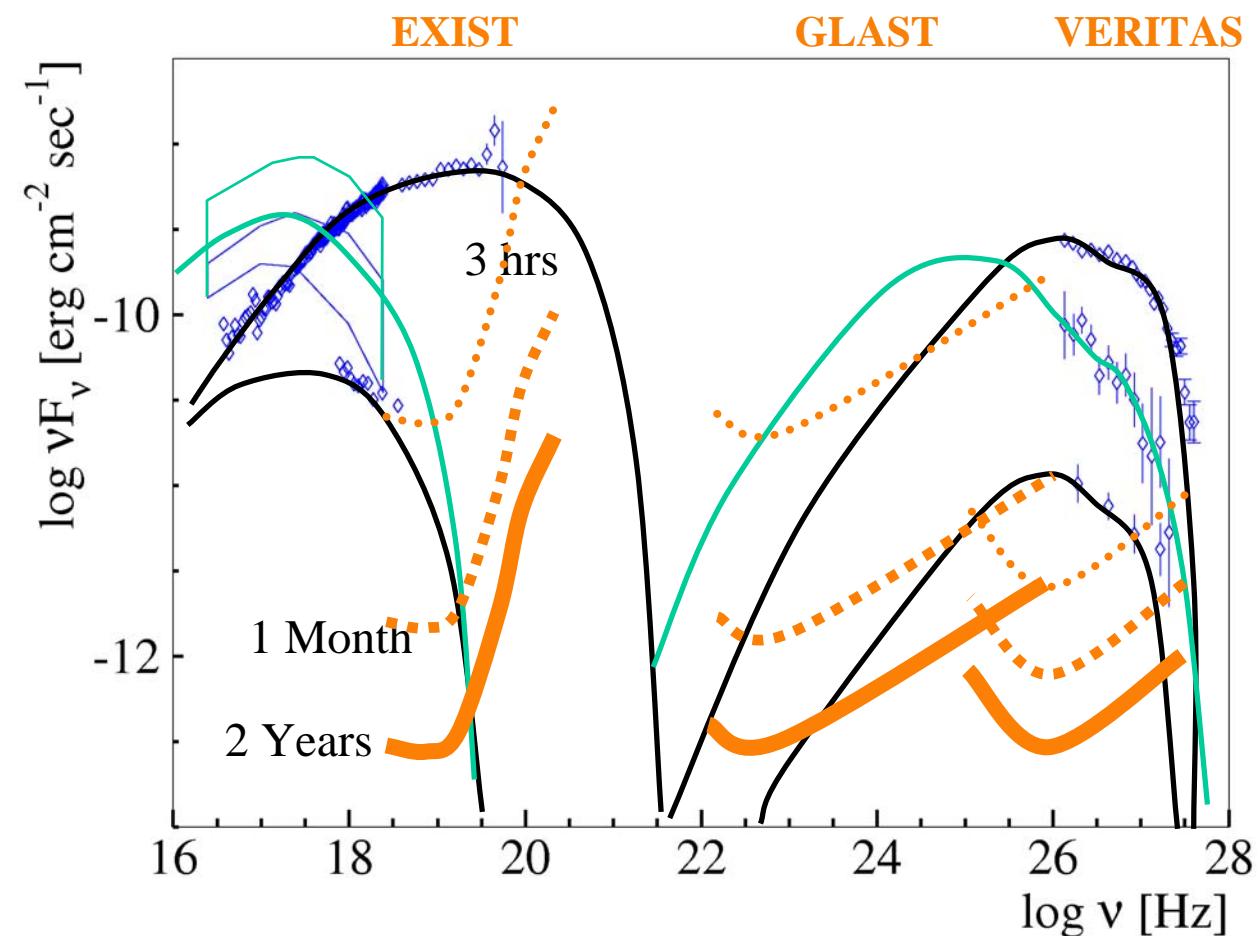


Krawczynski, Coppi, Aharonian et al. 2002

Conclusions:

- $L_{\text{rad}} = 10^{39} \text{ ergs cm}^{-2} \text{s}^{-1}$;
- $L_{\text{jet}} = 10^{43} \text{ ergs cm}^{-2} \text{s}^{-1}$;
- $\delta > 10$;
- $B \sim 0.3 G \times \delta/25$.

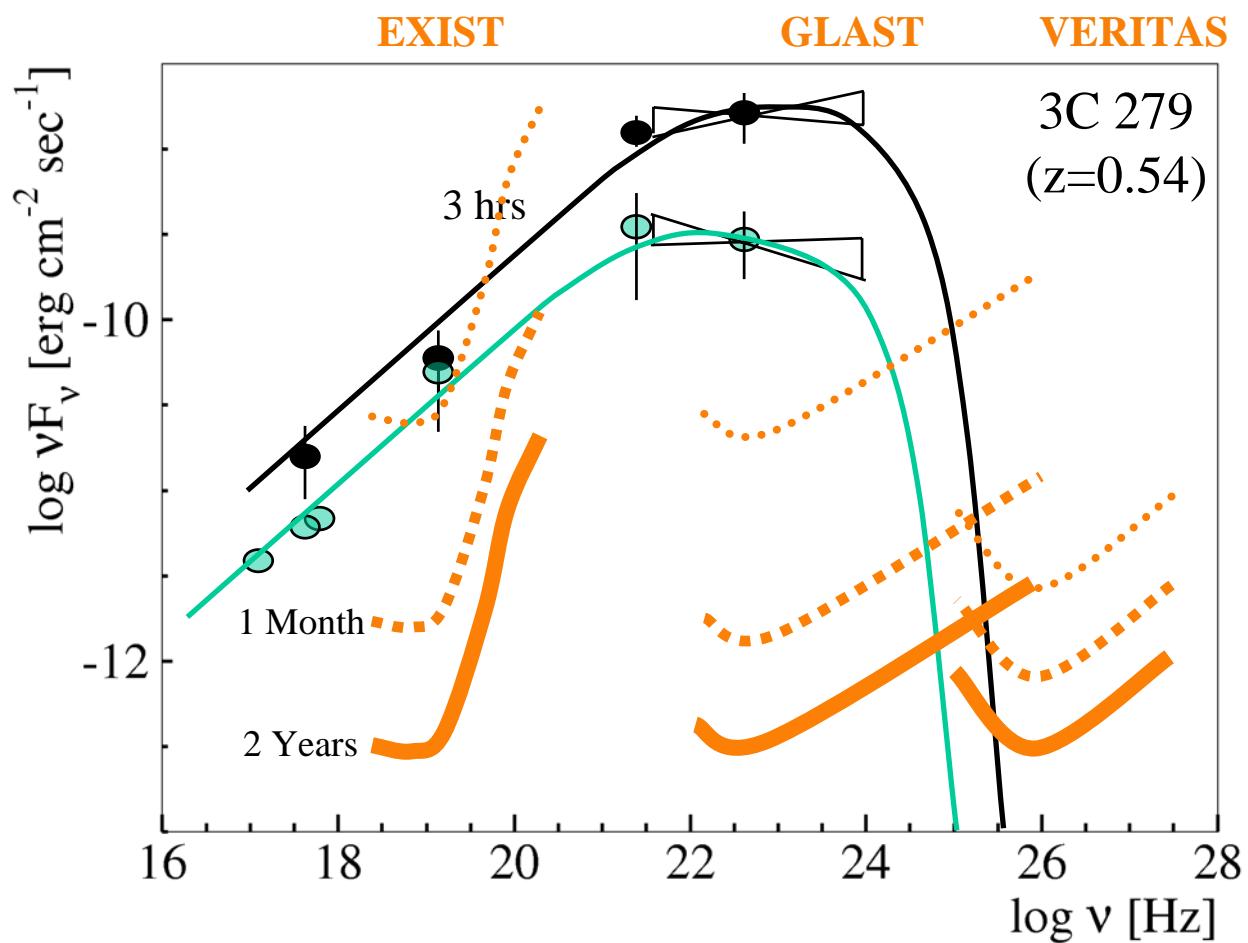
Telescope Sensitivities For TeV Blazars



EXIST Will Sample
Synchrotron Component
of TeV Blazars.

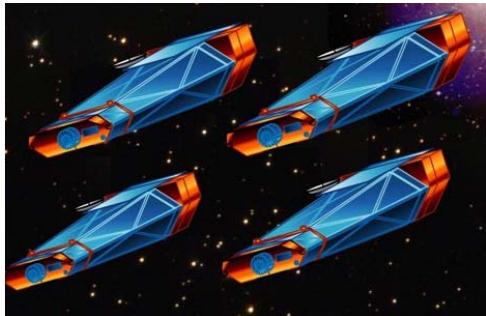
Good Match Also for
Next Generation γ -Ray
Telescopes

Telescope Sensitivities for MeV/GeV Blazars



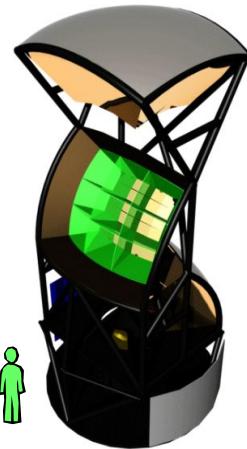
EXIST Will Sample IC Component of MeV/GeV Blazars.

Blazar Studies In 2018



Con-X
(0.1-40 keV)

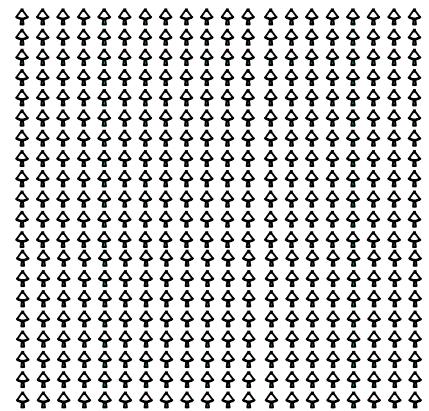
Accretion
Disk-Jet
Connection



EXIST
(10 keV-600 keV)

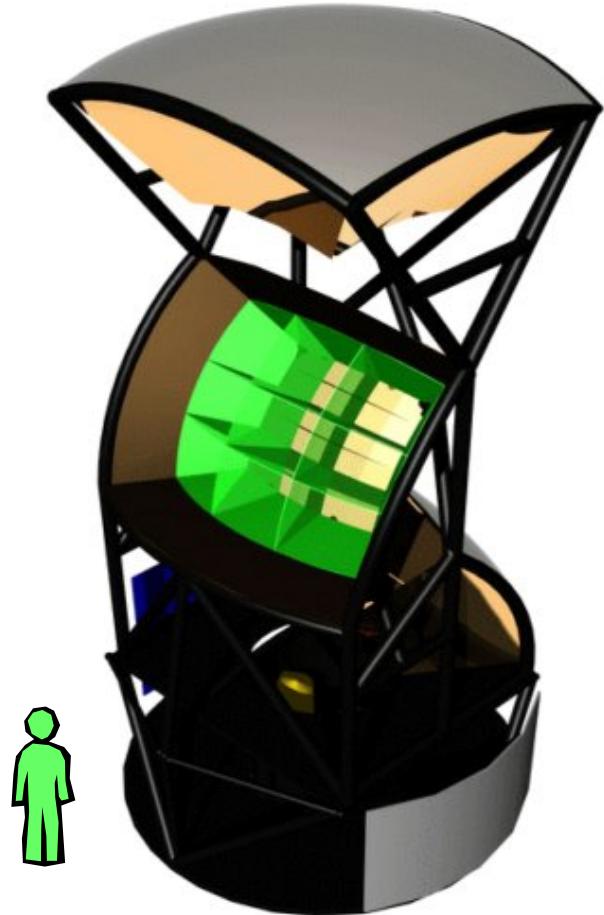


Redshift
Dependent
CIB



STAR
(10 GeV-10 TeV)

EXIST Black Hole Finder Probe

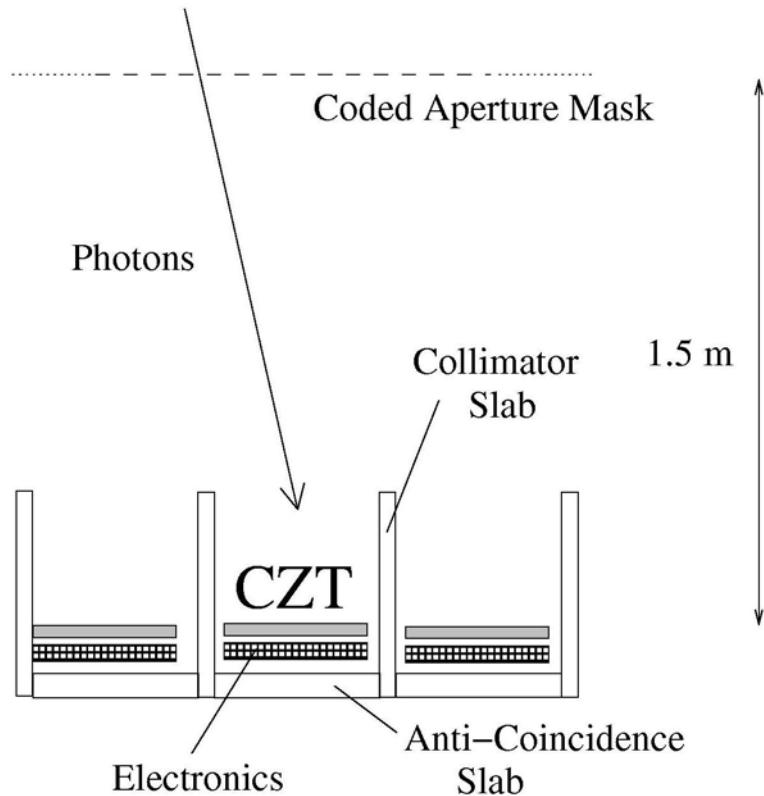


Grindlay (Harvard) et al., Caltech, Cambridge, CESR, Clemson, Columbia, Fisk, GSFC, Harvard, LLNL, MIT, MSFC, NRL, NSSTC, Rome Obs., SLAC, UCB, WUSTL, UCB, UCSB, UCSC, UCSD LLNL, WUSTL, Yale

Study of Black Holes:

- Obscured AGNs and Accretion History of Universe;
- Gamma-Ray Bursts;
- Galactic Black Holes.

EXIST - Principle of Operation



CZT Detectors:

- $\sim 10 \text{ keV}-600 \text{ keV} \rightarrow$
0.5 cm thick.
- $\sim 8\text{m}^2$ Area \rightarrow
16,000 Detector Units.

Shielding:

- CZT Requires Active Shielding.

CZT Research

Horizontal Bridgman (HB)

- eV Products, Bicron
- $\$2000 \text{ cm}^{-3}$
- $10^{11} \Omega \text{ cm}$

Project 1:
Get the Most Out
of Imarad CZT.

Earlier Work:
Narita et al. (1999,2001),
Hong et al. (2003),
Nemirovski et al. (2001)

Modified Horizontal Bridgman (MHB)

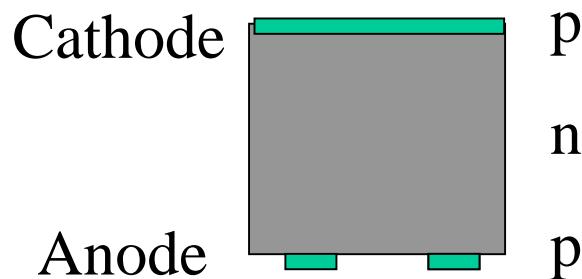
- Imarad
- $\$350 (\$50) \text{ cm}^{-3}$
- $10^{10} \Omega \text{ cm}$

Project 2:
Maximize Active
Volume
(CZT and CdTe).

Project 1 - Contacting Imarad Detectors

Aim: Improve Low-Energy Response

1.) Minimize Leakage Current:



$$FWHM_{sh} = 5 \text{ keV} \sqrt{\frac{I_d}{10 \text{nA}} \cdot \frac{\tau}{2 \mu\text{s}}}$$

2.) Minimize "Excess Noise".

Systematically Test:

- Surface Preparation;
- Contact Materials;
- Post-Deposition Treatments.

Re-Use the Same Detectors Over and Over Again.

Detector Fabrication



Surface Preparation:

- Polish;
- Wet Etching.

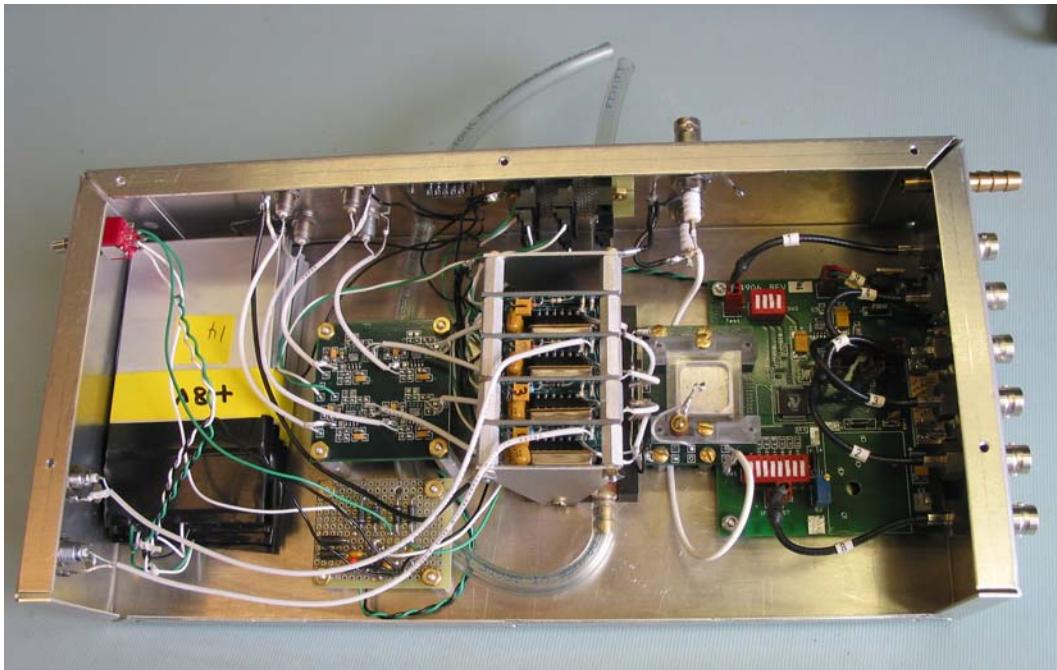


- Electron Beam Evaporation;
- Sputtering;
- Thermal Evaporation.

Post-Deposition Treatment:

- Baking.
- Wet Treatments;
- Oxygen Plasma.

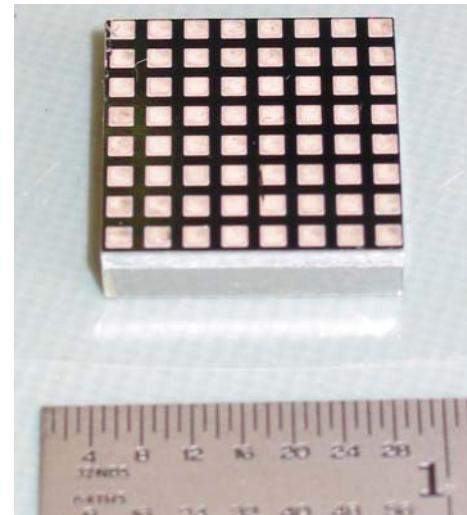
Test Setup



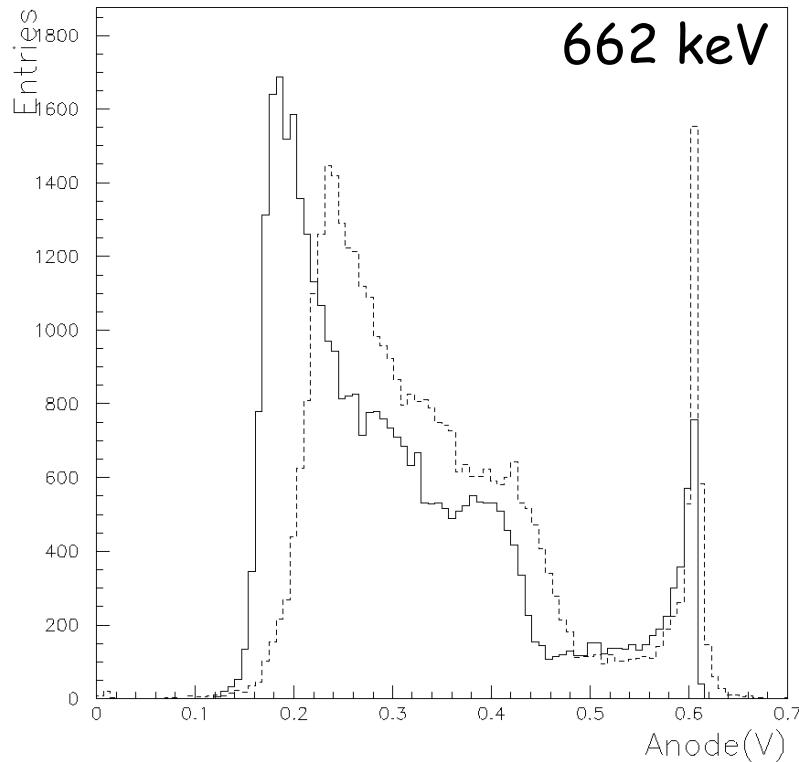
Noise: ~5 keV

Imarad Standard
Detector:

- $2 \times 2 \times 0.5 \text{ cm}$;
- 8×8 In Pixels;
- 2.5 mm Pitch.



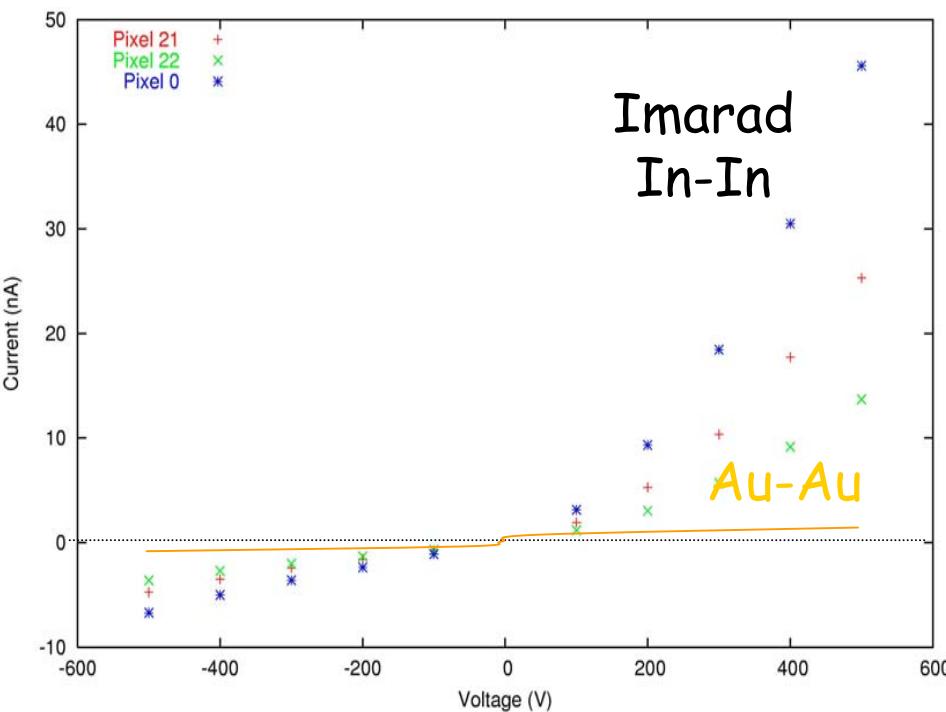
Standard Imarad Detectors



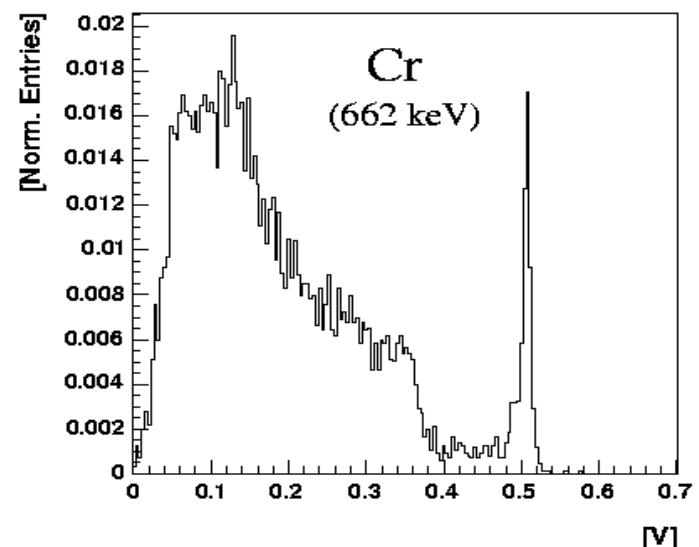
- 662 keV Energy Resolution (FWHM) : 10 keV
- 59 keV Energy Resolution (FWHM) : 7 keV
- Active Volume : 67%

Performance of Alternative Contacts

I-V Curves:



Energy Spectra:



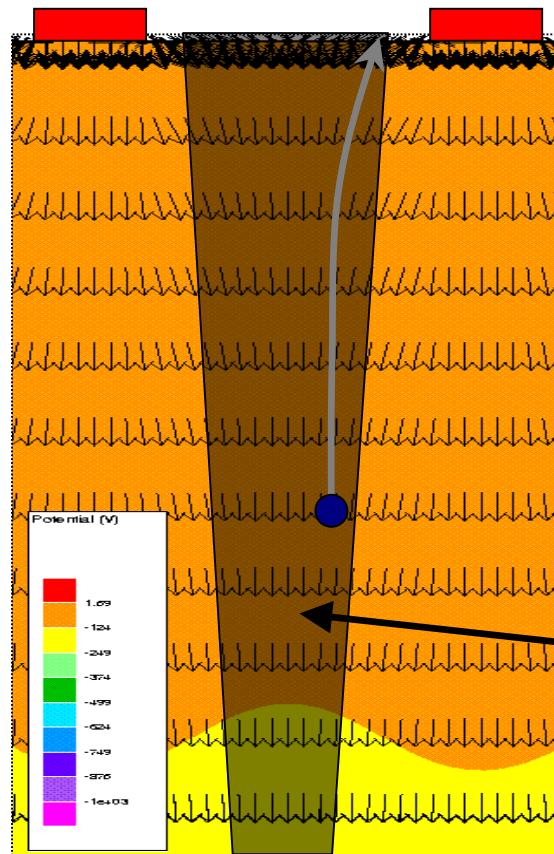
662 keV: 59 keV:
12 keV 11 keV

High Workfunction Metals
(Cr, Au, Au, Pt)
Reduce Leakage Currents.

No Improvement In
Energy Resolution.

Project 2 - Optimization of Steering Contacts

Anode
Pixels
(0 V)

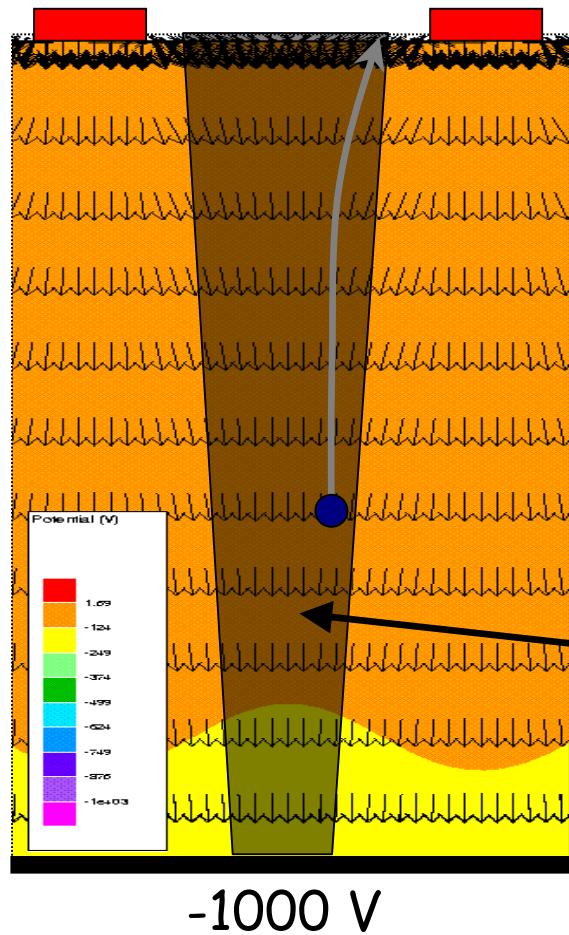


E-Field
Dead Region



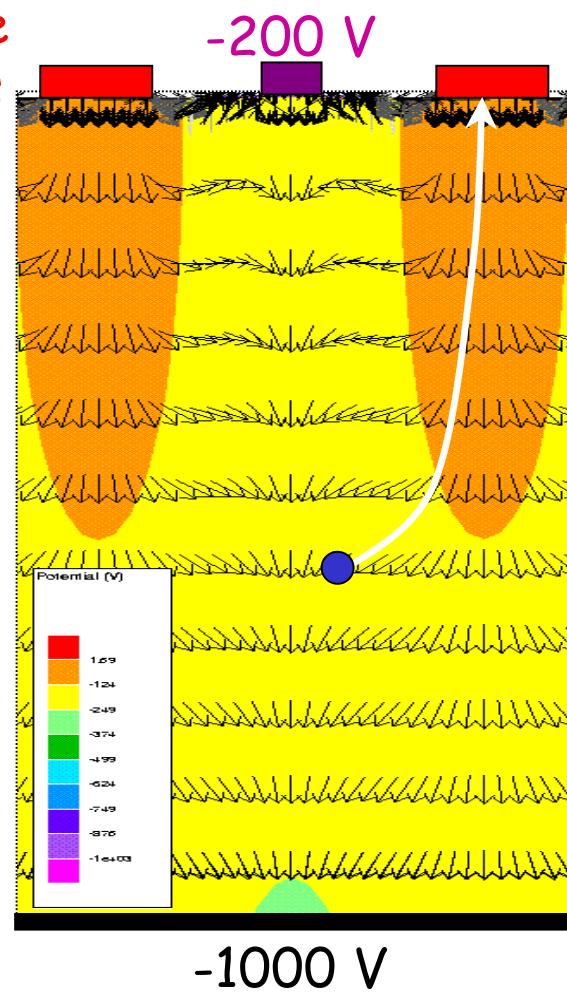
Project 2 - Optimization of Steering Contacts

Anode
Pixels
(0 V)



Dead
Region

Anode
Pixels
(0 V)



Using the EXIST Shield As A GRB Spectrometer

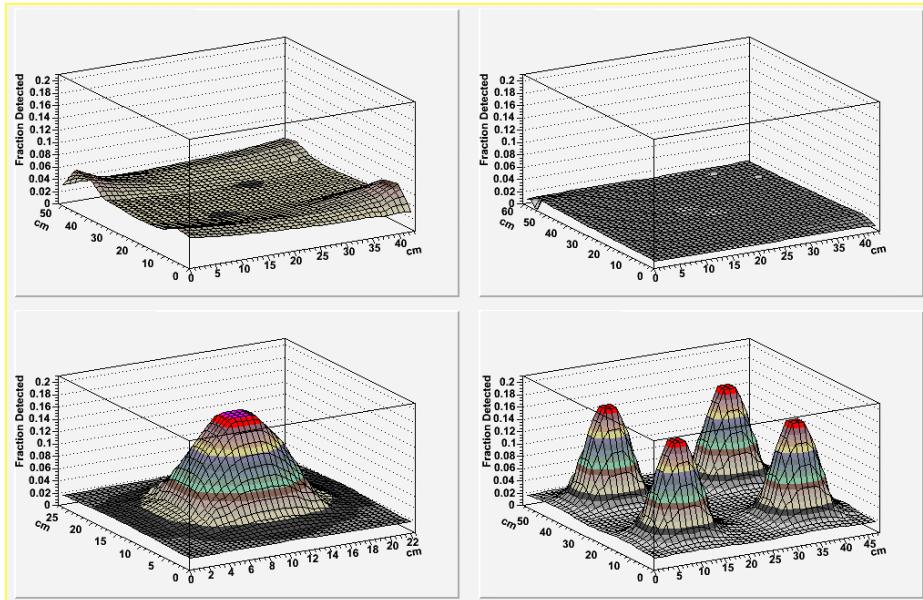


Up to 35 m^2 of CsI

- Shield:
 - Complements CZT Detectors at Energies Above 300 keV
 $\rightarrow E_p, \alpha, \beta, \Delta t_{hs}$

Shield Simulations (Garson et al.)

CsI Slabs (Detect2000):

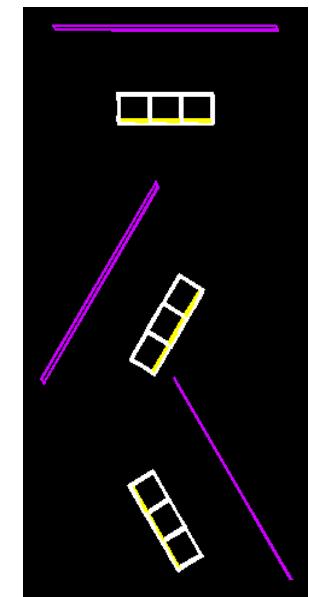


Interactions (GEANT 4):

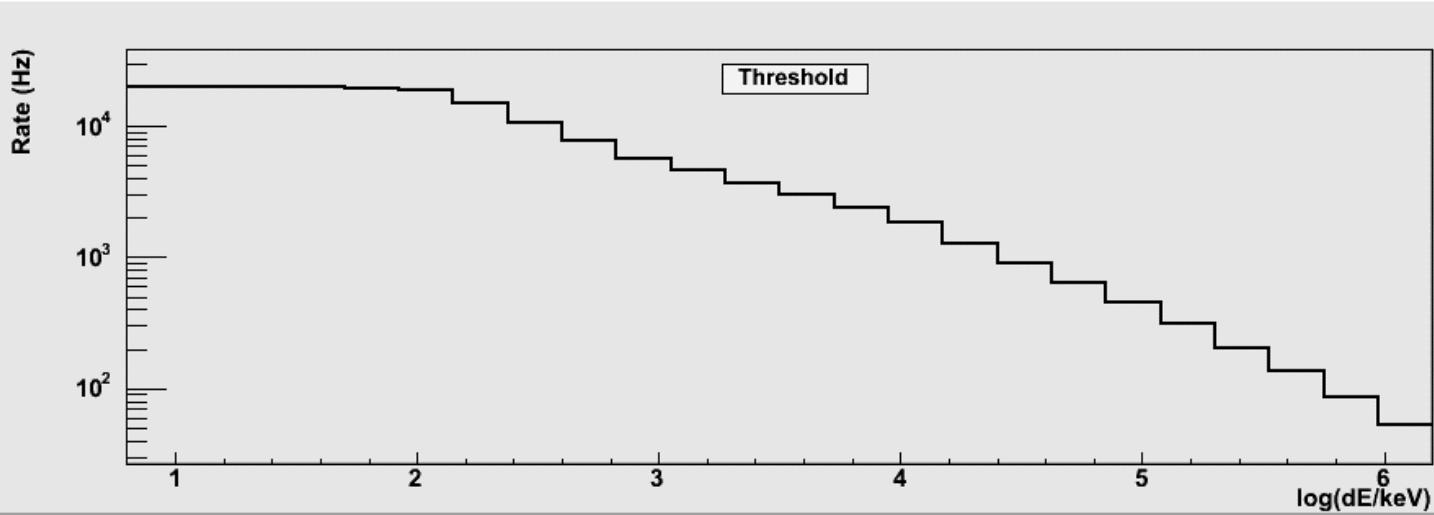
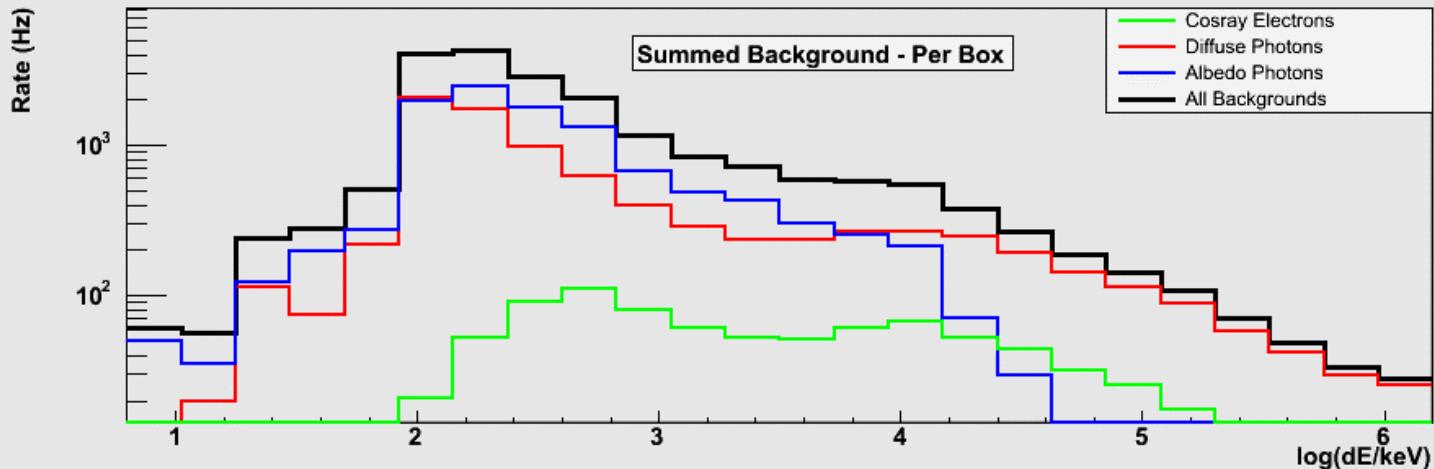
Tungsten Coded Mask

CsI(Na) Shield

CZT Detectors

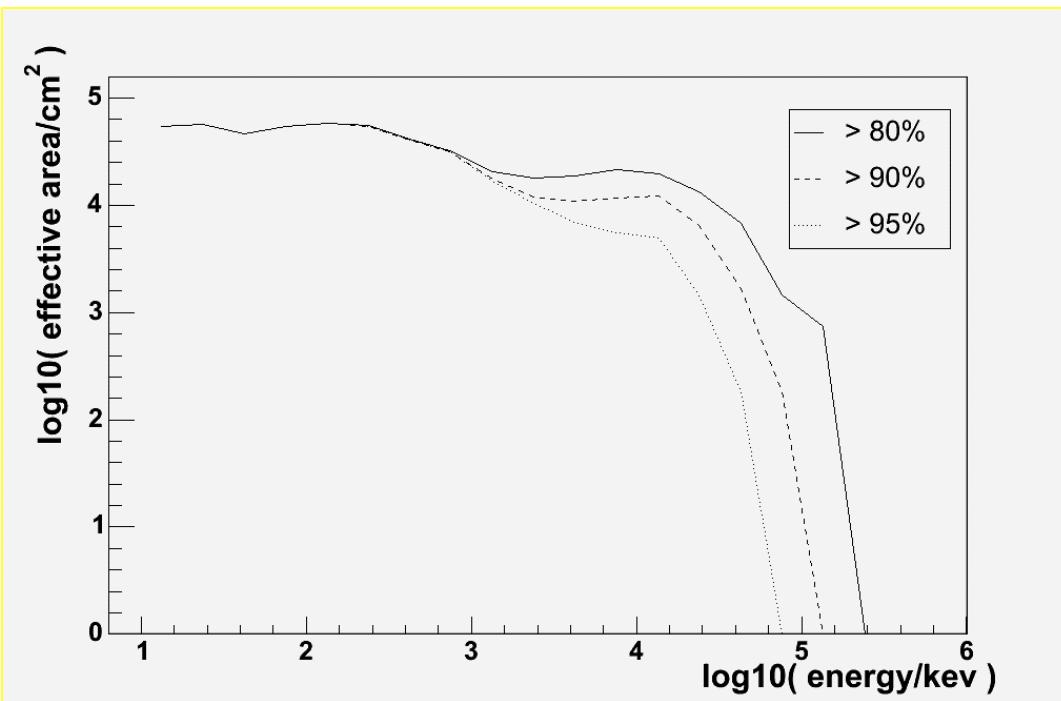


Background Simulation



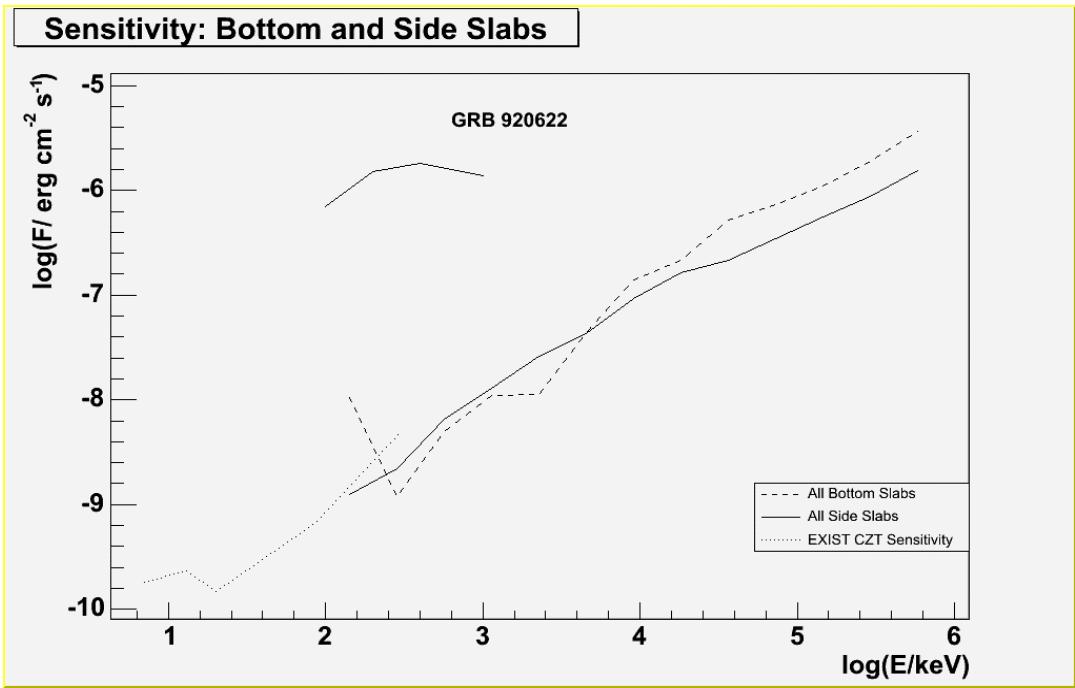
Diffuse and Albedo Photons Dominate

Effective Area



Effective Area
Depends on Burst
Direction

Sensitivity



Shield
Complements CZT
Detector Nicely.

Summary

- Blazars: Study Jets at Their Bases, Less Than 1pc From the Black Hole.
- CZT:
 - Imarad: Contacting, Encapsulation, and Passivation;
 - Steering Contacts: Increase Active Volume.
- EXIST CsI-Shield:
 - GRB Spectroscopy from 100 keV-100 MeV.